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JUN 80 J A VOGEL, J E WRIGHT, J F PATTON

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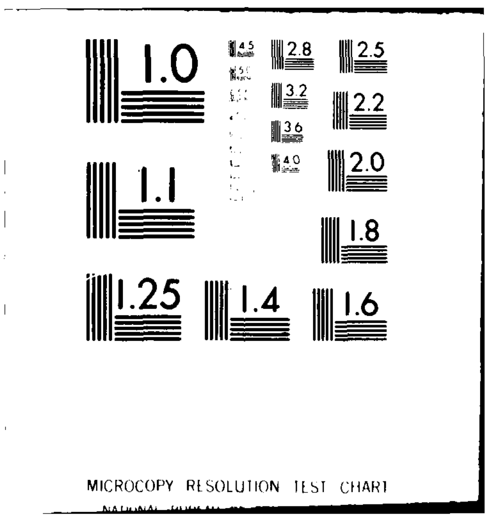

MICROCOPY RESOLUTION TEST CHART

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DEVELOPMENT OF NEW GENDER-FREE PHYSICAL FITNESS STANDARDS FOR THE ARMY

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I. Introduction

The General Accounting Office recommended to the Armed Services in May 1976 that they --"develop standards for measuring the ability of personnel to satisfy strength, stamina and operational performance requirements for specialties where such attributes are factors in effective performance". This action was in response to the arbitrary closure to women of many military occupational specialties (MOS) presumed to be too physically demanding.

With the need to utilize increasing numbers of women in non-traditional MOSs as well as to respond to affirmative action policies, it became apparent that the Army must qualify and assign new entrants by matching individual qualifications with specific MOS physical requirements, regardless of gender. Arbitrarily barring all women from a physically demanding MOS, because it is beyond the capacity of the average woman, is wasteful of manpower, if not, unjustifiable. Thus, in July 1977, the Army Vice Chief of Staff directed that research begin to establish gender-free occupationally related physical fitness standards which could be used for MOS selection and assignment. This paper presents the process by which this has been accomplished.

II. Background

The process was based on the following series of assumptions.

Assumption No. 1: Standards should be

established for two separate components of physical fitness - aerobic fitness and muscle strength fitness.

Physical fitness can best be defined in terms of the various capacities of the body to carry out physical activity. These capacities are best described by the sources or processes of energy generation for muscular exertion. These energy sources are physiologically quite distinct and therefore no single capacity or fitness measure is adequate to encompass physical fitness in the terms necessary to define the variety of Army MOSs.

Physiologically there are three distinct energy sources and thus three physical fitness components. These are illustrated in Figure 1. Energy for brief muscular activity, such as the lifting of

MUSCLE ENERGY SOURCE	STORED	ANAEROBIC METABOLISM	AEROBIC METABOLISM
EXAMPLE OF ACTIVITY	LIFTING	SPRINTING	RUNNING
CAPACITY MEASURED AS	MAXIMAL CONTRACTION FORCE	ENDURANCE TIME AT HIGH INTENSITY	MAXIMAL O_2 UPTAKE
TERMINOLOGY	MUSCULAR STRENGTH	ANAEROBIC POWER — MUSCULAR ENDURANCE	AEROBIC POWER — STAMINA

Figure 1. Components of physical fitness in terms of energy sources

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boxes or artillery rounds, is predominantly provided from energy (in the form of phosphate compounds) stored in the muscle cells. On the opposite end of the spectrum, energy to sustain long term dynamic movement, such as running or repetitive light lifting, is provided from metabolic pathways which utilize oxygen to convert substrates into useable energy. The third energy source which plays an intermediate role between stored and aerobically derived energy is that derived from anaerobic metabolic pathways. In this latter system, conversion of substrate to energy does not require oxygen. This source is utilized when stored energy is depleted and the demand rate exceeds the velocity and capacity of the aerobic system.

Most physical exertion is in fact a combination of these fitness components. While strength and aerobic fitness are relatively easy to isolate and identifiable, anaerobic fitness overlaps extensively with the other two and is quite difficult to separate and measure. It is for this reason, as well as simplicity, that in establishing occupationally related standards, it was decided to operationally use only two components of fitness, muscular strength and aerobic fitness.

> Assumption No. 2: Standards should be based on objectively determined physical demands of MOSs.

The capability exists to actually measure the aerobic energy costs and calculate the forces exerted in individual tasks performed in the field. Thus, standards based objectively on actual physiological demands are preferable to subjective determinations of task demands, i.e., impressions, perceptions, estimations or judgements.

> Assumption No. 3: Standards should be established for groups or clusters of MOSs having apparently similar fitness requirements.

There are approximately 350 enlisted Army MOSs. Many have similar, if not identical, physical tasks and therefore physical fitness requirements. For this reason as well as simplicity and ease of administration, the smallest number of different fitness standards would be desirable. Thus, MOSs having apparent similar physical demands would be grouped together so as to reduce to the minimum the number of established standards.

Assumption No. 4: Standards should be based on the most demanding tasks found within each MOS grouping.

Since a soldier must perform every task within his MOS, it was decided to establish standards based on the most demanding tasks within that MOS grouping. This process was selected instead of using the average demand of all tasks.

Assumption No. 5: The resolution or sensitivity of the scale of standards should be commensurate with operational needs.

The application or administration of fitness standards in the field must be simplified as much as possible if they are to be accepted at all. This is due to the magnitude and diversity of Army personnel and their locations. A scale of standards with many graduations would defeat the purpose intended. Sufficient resolution however, should be established which separates any differences in aerobic and muscular strength demands which are meaningful in terms of job performance.

III. Methodology

A summary of the steps developed to derive gender-free, occupationally related physical fitness standards is shown in Figure 2.

Step No. 1. The initial step of this process was to assemble a list of all physically demanding tasks for each MOS. Each Army service school provided a detailed description of the physically demanding tasks of MOSs for which they are the proponent. Provision of insufficient information or unrealistic descriptions were rechecked and verified until the investigators were satisfied that the information was accurate.

Step No. 2. The next step was to visually inspect these physical task lists and group MOSs into clusters with similar fitness demands by using a set of objective criteria. These clustering

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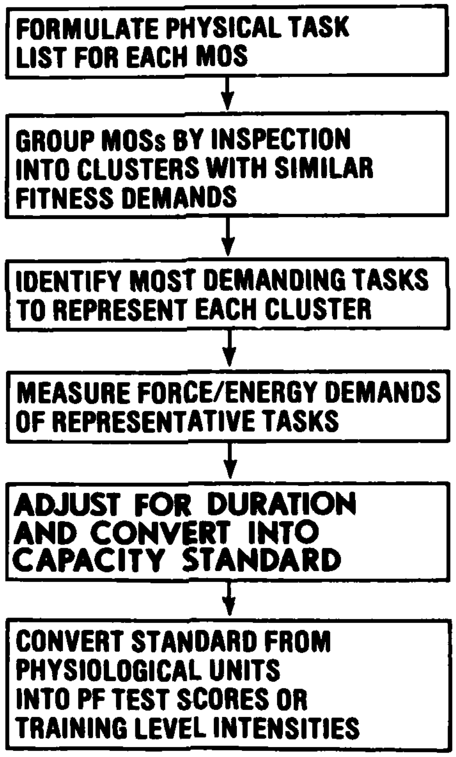

Figure 2. Sequence of steps taken to develop occupationally related fitness standards.

criteria are shown in Table 1. These criteria, one for muscular strength and one for aerobic power demand, were derived by plotting the full range of individual task values observed in the task list and then establishing three levels which divided the total range into approximately equal parts by taking into account natural concentrations of points. This process is illustrated in Figure 3.

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TABLE 1. MOS Clustering Criteria

Intensity Rating	Strength Demand (kg weight lifted to waist height)	Aerobic Demand (energy cost in kcal/min)
Low	<30	<7.5
Medium	30-40	7.5-11.25
High	>40	>11.25

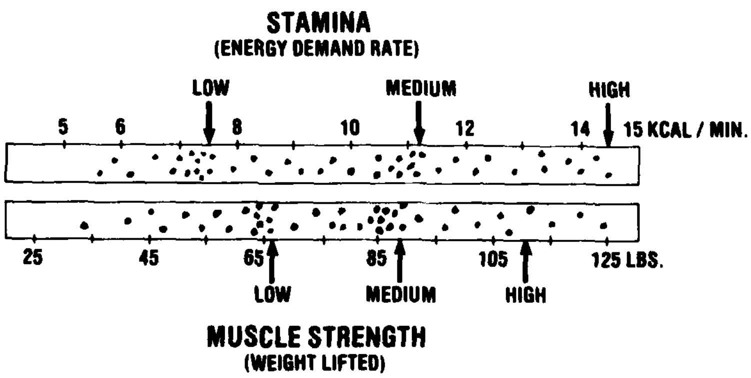

Figure 3. A representation of how objective criteria were chosen for MOS clustering.

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Step No. 3. Once the grouping had been completed and clusters of MOSs with like demands were formed, the task lists of each cluster were again examined to select those to be the most demanding. Four to six of the most demanding tasks in each cluster in terms of aerobic power were selected for detailed physiological analysis. These selections were made by evaluating weights lifted, heights to which lifted, distances carried and estimated caloric expenditure of the task. The latter was based on previously published energy costs of both civilian and military tasks (1-3).

Step No. 4. The next step consisted of actually measuring the energy costs and verifying the weights lifted and distances moved for the representative (most demanding) tasks. Soldiers from the Training Center, Ft. Jackson, SC and the 24th Infantry Division, Ft. Stewart, GA were utilized for these measurements.

Caloric costs of tasks were determined by measuring oxygen consumption with the Kofranyi-Michaelis portable respiratory gas Meter (3). The subject inspired through a mouthpiece and valve so that the expired air was delivered to the meter carried as a back pack (weight of 3.8 kg). The meter directly measured expired ventilation and produced an aliquot of gas for separate fractional analysis of oxygen and carbon dioxide. These two gas concentrations plus expired minute ventilation were used to calculate the oxygen consumed each minute. This was converted to kilocalories using the conversion ratio of 5 kcal per liter of oxygen consumed.

Step No. 5. The energy cost of the tasks selected in Steps No. 3 and 4 was measured over a period of time (10-20 minutes) sufficient to produce a stable period of oxygen consumption. This period did not necessarily have to equal the actual length of the task as described but only long enough to accurately ascertain the average energy expenditure rate of the task being performed at the prescribed intensity. Most tasks were considered as being performed on a sustained basis (short rest to work period ratios) and therefore the measured rate was utilized as the eight hour average sustained rate.

The next step was the crucial one of converting the eight hour sustained energy cost rate into the necessary aerobic capacity for an individual to perform at that level of intensity. A number of reports (4-6) have suggested that average energy expenditure rates for an 8 hour work day should not exceed 35 to 50% of one's aerobic capacity in order to prevent an inordinate amount of fatigue from which one could not recover overnight. Thus, using a 45% figure, if the highest energy cost of a representative task was found to be 8 kcal per minute, then a person would be required to possess an aerobic capacity of not less than 18 kcal per minute or a maximal oxygen consumption of 3.6 liters per minute. We employed the percentage figure of 45% which will be discussed later. At this point, the requirement or standard was established in terms of physiological units (kcal or liters of oxygen) for aerobic demand and physical units (weight and distance) for strength demand.

Step No. 6. The final step was to convert these physiological and physical units of capacity into two sets of physical fitness test scores, one to be applied at the time of entrance qualification and the other on-the-job within the MOS (Figure 4). The differences between these two tests are in the mode of testing and the test score

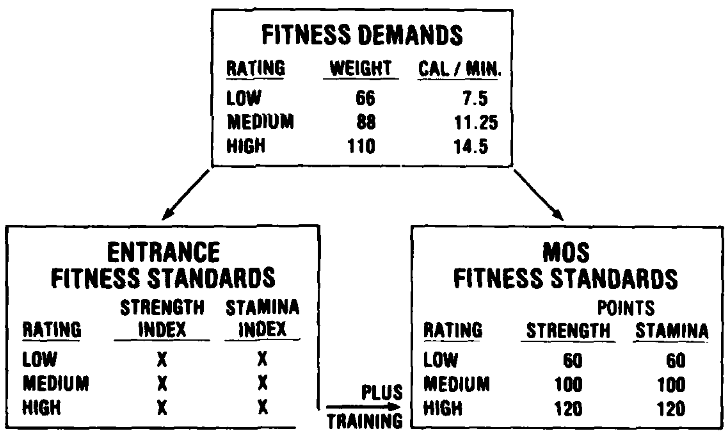

Figure 4. Scheme for Converting MOS Demands into Entrance as Well as On-The-Job Standards.

standard. The entrance test would be administered at the Armed Forces Examining and Entrance Stations (AFEES) where laboratory type equipment and procedures can be utilized to yield relatively precise measures of aerobic and strength capacity. In the "field", on-the-job, we are limited to the use of performance tests such as running, push-ups, etc. The other difference is that the entrance standard will be less than the "on-the-job" standard by an amount equal to the average expected gain during basic and advanced individual training. The test measures presently being considered are listed in Table 2.

Table 2

Physical Fitness Test Measures for Entrance and On-the-Job

Component	Entrance (AFEES)	On-the-Job
Aerobic	Heart rate during step test plus % body fat.	2 mile run
Muscle strength	Isometric upright pull at 38 cm.	Push-ups Sit-ups

Capacities from Step No. 5 are then converted into equivalent scores on these two sets of tests through the means of regression analysis. The aerobic capacity and two mile run relationship is illustrated in Figure 5 and the muscle strength-isometric pull relationship is illustrated in Figure 6.

IV. Results

A. Physical Task List

Based on information provided by the service schools, the physical tasks of 349 enlisted MOSs were compiled. An example of a task write-up is given below:

> MOS 12E, task-1: Backpack an ADM.
>
> Condition: given an XM120E1 in the H-911 bay secured to the backpack, cross-country route, under daylight conditions.

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Standard:

i. lift a 30 kg XM120E1
ii. backpack ADM 1 km
iii. perform task in 20 minutes
iv. perform task 2 times per day

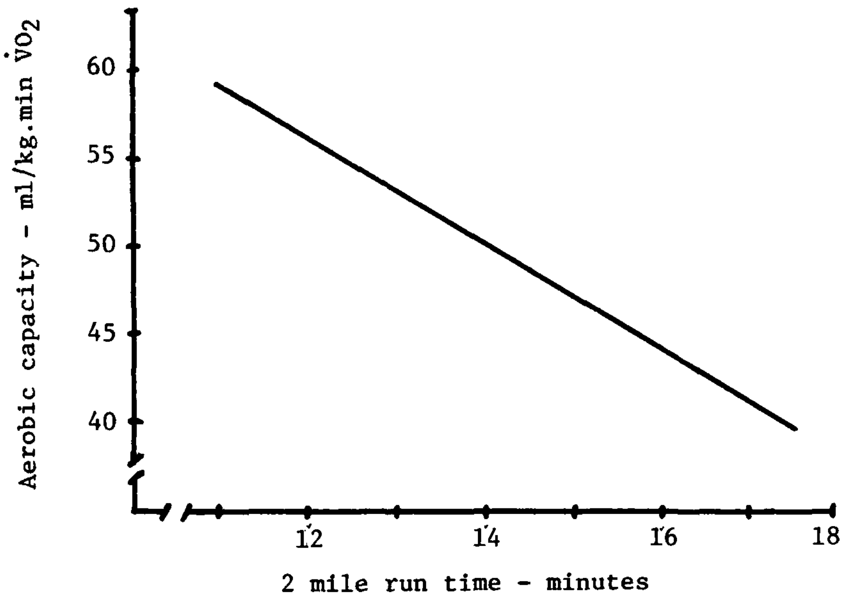

Figure 5. Relationship between aerobic capacity and 2 mile run time.

B. Clustering of MOSs by Fitness Demand

Using the procedure of judging task demand in two categories at three levels of intensity (Table 1), five clusters resulted out of a possible nine combinations (Table 3). Table 4 presents the five clusters in terms of distribution of MOSs and personnel.

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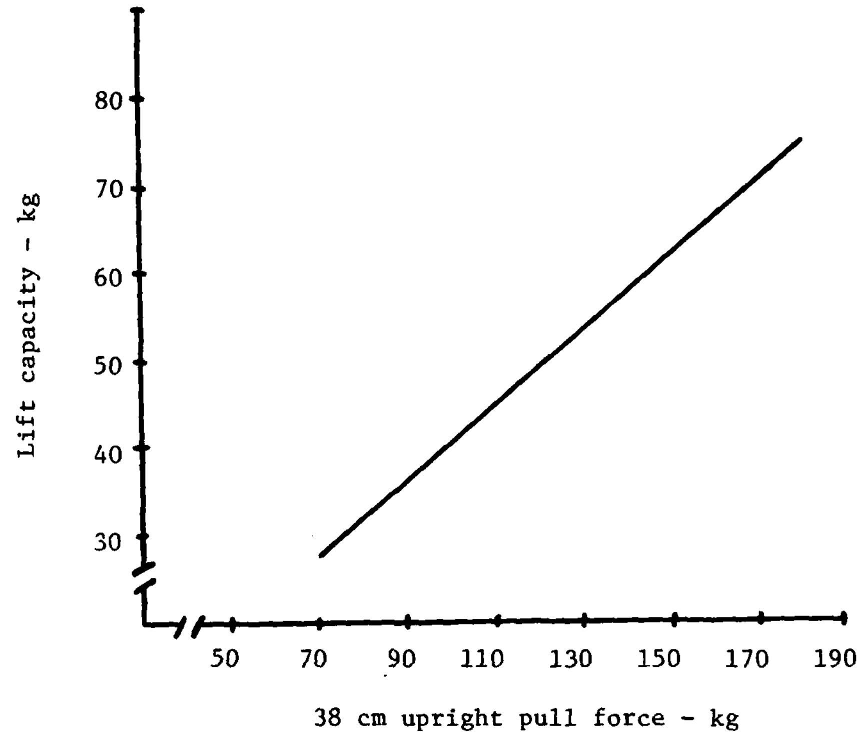

Figure 6. Relationship between maximum lift capacity and isometric upright pull test.

Table 3

MOS Clusters

Level of Demand: Strength	Aerobic	Cluster Designation
High	High	Alpha
High	Medium	Bravo
High	Low	Charlie
Medium	Low	Delta
Low	Low	Echo

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Table 4

MOS Cluster Distribution

Cluster	Number of MOSs	% of Total MOS	% of total Personnel
Alpha	10	3	19
Bravo	39	11	13
Charlie	63	18	21
Delta	53	15	21
Echo	184	53	26
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C. Representative Most-Demanding Tasks

Table 5 presents an example of representative tasks selected for each cluster to be used for cost measurements. Special note should be taken of the Echo cluster tasks. Echo cluster includes all MOSs which have no, or only minimal, physically demanding tasks within their job description. Thus, there were no physical tasks upon which to base a fitness standard. It was therefore decided by HQ-Training and Doctrine Command that a group of tasks would be formulated which would be used to derive the fitness standard. These tasks, referred to as "common soldiering tasks", were selected by a committee at the US Army Infantry School to represent those tasks which all soldiers must be able to perform, at a minimum, in a wartime defensive situation. These are also tasks which are to be accomplished by the end of Basic Initial Entry Training.

D. Measurement of Energy Cost

Table 6 presents examples of mean energy costs of a representative task from each cluster.

E. Convert Cost into Capacity and Test Standards

Demand for muscular strength was expressed in terms of weight lifted to a height of 132 cm. Thus, the greatest lifting demands identified in the cluster representative tasks were converted into this unit (adjusted for height lifted) and expressed as the required absolute strength capacity. For aerobic capacity, 8 hour energy demands were set not to exceed 45% of capacity and aerobic capacities thereby calculated.

Table 5

Examples of Cluster Representative Tasks

Alpha
"Carry 45 kg CWIE bag 1000 m in 20 minutes."

Bravo
"Lift and carry 41 kg ammo box 6.7 m 32 times per hour."

Charlie
"Lift 132 cm and carry 25 kg projectile 15 m, 50 times per hour."

Delta
"Lift and carry 27 kg container 15 m, 40 times per hour."

Echo (complete list)
1. "8 km march in 120 minutes."
2. "Dig one-man emplacement in 45 min."
3. "Lift and carry 23 kg, 50 m, 8 times in 10 min."
4. "Rush 75 m in 25 sec."
5. "Low and high crawl 75 m in 90 sec."

The conversion of these physical and physiological units into field test event scores or AFEES measurement scores is then carried out by regression analyses as described earlier. The purpose of this paper is to present the process used to derive these standards and therefore the actual computed standards are not presented but will be published elsewhere.

IV. Discussion

This paper outlines the rationale and step-by-step process taken to develop new gender-free physical fitness standards for the Army based solely on occupational (MOS) physical demands. It establishes an objective basis for minimum physical standards for MOSs so that individuals can be selected and assigned to MOSs based on the

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physical demands of the MOS. It is recognized that a number of assumptions must be made during this process, some of them based on inprecise data. However, it is felt that the precision achieved is appropriate to the resolution desired.

Table 6

Examples of task energy cost from each cluster

Cluster	Task	Cost 1/min $\dot{V}O_2$
Alpha	Carry 50 43 kg bags 20 ft in one hr.	0.96
Bravo	Lift 45 kg projectile to 132 cm and carry 20 m, 100 times per day.	0.89
Charlie	Lift and carry 25 kg projectile 15 m, 50 times per hr.	0.75
Delta	Lift and carry 27 kg container 15 m, 40 times per hr.	0.73

Occupationally based fitness standards are not meant to be either the ultimate or sole physical fitness standards. They are intended to serve as a requirement upon which to base MOS assignment qualification at the time of enlistment into the Army and secondly as the minimal standard that must be met to retain qualification in a particular MOS or for retention in the service. It is envisioned that, particularly in operational units, these MOS-based standards would be exceeded in order to achieve the additional goals of improved health, appearance, morale and overall military performance. These additional or supplemental standards would be determined by unit commanders to meet the needs of their personnel and their unit mission.

In conclusion, this research has resulted in a process by which physical fitness demands of all enlisted MOSs can be represented by 5 sets of standards, representing three levels of demand in two separate categories of fitness. This categorization was accomplished by applying objective criteria to MOS tasks, including the weight lifted and rates of energy expended. This system establishes a basis by which physically demanding occupations can be assigned on a gender free basis which will be both legally and scientifically defensible.

It should lead to more cost effective matching of individual capabilities to occupational demands.

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